LROC NAC PHOTOMETRY OF THE APOLLO 16 LANDING SITE: CORRELATING FELDSPATHIC COMPOSITIONS USING LANDING SITE AND SAMPLE DATA. R. N. Watkins[1,2], B. L. Jolliff[3], A. Boyd[4], N. Gonzales[4], E. Speyerer[4]. [1]Planetary Science Institute, 1700 E Fort Lowell Rd., Tucson, AZ 85719, [2]Arctic Slope Regional Corporation Federal (RWatkins-02@asrcfederal.com), [3]Washington University in St. Louis and the McDonnell Center for the Space Sciences, St. Louis, MO 63130, [4]Arizona State University, Tempe, AZ.

Introduction: High-resolution imagery from the Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Cameras (NACs; 0.5-2 mpp) combined with Apollo ground-truth sample data allows for robust investigations of the geology of the lunar surface. Previous investigations [1,2] have correlated mineralogy of Apollo samples with photometric parameters derived from LROC NAC imagery. Recent work by [2] correlated photometric parameters with sample data from 30+ sample stations at the Apollo 17 landing site and found a strong correlation between mafic mineralogy, represented by $FeO+TiO_2+MgO$, and single scattering albedo (*w*; decreases with increasing mafic content, or, conversely, increases with increasing plagioclase or Al_2O_3 content); however, the Apollo 17-based correlation did not extend to more feldspathic compositions such as anorthosite.

Here, we present data to extend compositional and photometric relationships to highly feldspathic compositions by assessing Apollo 16 sample data and photometric parameters derived from LROC NAC imagery and Hapke photometric modeling. Demonstrating a robust correlation between the composition of soil samples and orbital measurements across a wider range of surface units provides a powerful tool for investigating the compositional diversity of regions that have not yet been sampled in-situ. Additionally, surface maturity has a strong effect on albedo [2], and with the presence of two fresh impact craters at the Apollo 16 site (North and South Ray craters), we can assess this affect quantitatively.

Methods: LROC NAC images of the Apollo 16 landing area were processed and map-projected using the USGS Integrated Software for Imagers and Spectrometers [3], and resampled to match the resolution (5 mpp) of the NAC Digital Terrain Model (DTM) that covers the landing area. The DTM was used to correct for the effects of local topography by computing local viewing geometries and *I/F* (reflectance) values for each pixel [2]. We used these values and nonlinear optimization techniques in MATLAB to minimize a simplified form of the Hapke equation [4] and determine optimum values for photometric parameters for each pixel. More details of the method can be found in [1,2]. The parameters of interest here are the single scattering albedo (*w*) and the *b*- and *c*- parameters of the single particle phase function within the Hapke model. The single scattering albedo depends mainly on composition, whereas *b*- and *c* are correlated with physical properties such as grain size/shape, glassy vs. crystalline content, agglutinate content, and backscattering characteristics [5,6]. Assessing variations in *w*, *b*, and *c* values and their relationship to measured properties (mineralogy, grain size, glass content, maturity, etc.) from Apollo 16 samples will enhance our ability to understand surface properties from remote sensing data. The resulting output is *w* and *b* maps of the Apollo 16 landing area at 5 mpp resolution (**Fig 1**; *c* values can be directly calculated from *b* [6] but are not shown here).

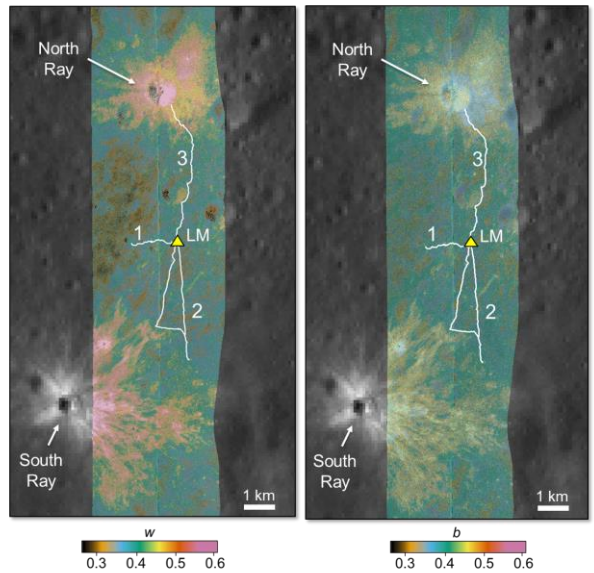

***Fig. 1**: LROC NAC-derived w (left) and b (right) maps of the Apollo 16 landing area, showing variations in local geology and regolith properties. White lines indicate EVAs, yellow triangle represents the Lunar Module.*

Sample Stations: Using a version of the process used by [7], which combines lunar rover TV footage, Hasselblad imagery, and post-mission traverse maps, sample collection sites were determined to within 3 m. Sample collection sites are based on the location of the first rock contained in a sample bag, and estimated to 3 m radius to account for sample bags containing several rocks from the immediate vicinity of the first sample.

Sample Characteristics: Data on the mineralogy and physical characteristics (grain size, maturity) for soil samples was obtained from the Lunar Sample Compendium [8] and the Grain Size Catalog [9]. These soil sample data were then compared to *w* and *b* values from each sample station to look for correlations.

Results: The *w* and *b* maps derived for the Apollo 16 landing area (**Fig. 1**) show subtle changes in the

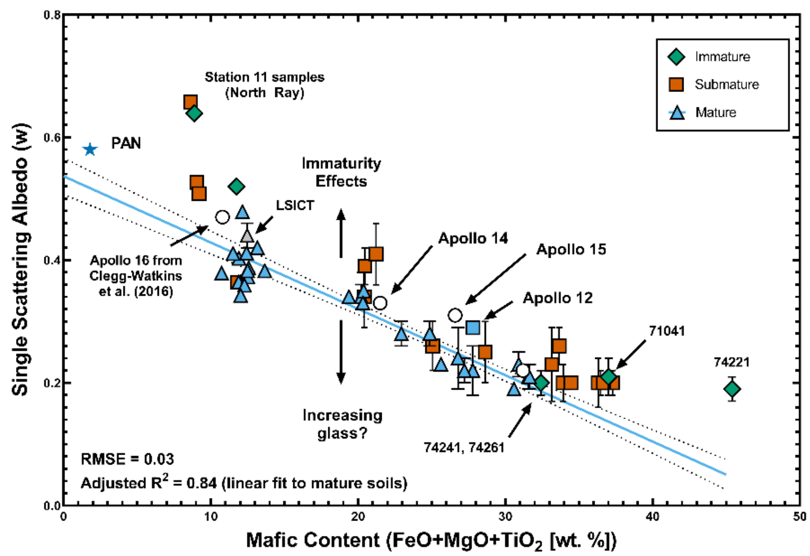

***Fig. 2**: Relationship between single scattering albedo and mafic mineralogy content as determined by Apollo lunar samples. Linear fit is to mature Apollo 16 and 17 soils. Maturity effects are clearly seen; immature and submature soils generally exhibit higher w values.*

vicinity of the Lunar Module and throughout most of the EVA regions, with the exception of the portion of EVA 3 that covered the rim and ejecta of North Ray crater and has higher values for both parameters. The *w* values for Apollo 16 sample stations range from 0.31-0.66, *b* values from 0.14-0.40, and *c* values from -0.71-1.47. The Apollo 16 soils have mafic content ($FeO+MgO+TiO_2$) ranging from 8.63-13.7 wt%, and, as expected, have higher *w* values than the previously measured Apollo soil samples of basaltic and nonmare, intermediate compositions (**Fig. 2**).

Discussion: As noted by [2], *w* is strongly affected by maturity. Immature and submature soil samples have *w* values that lie above the linear fit to mature soils (Fig. 2), and immature crater rays have visibly higher *w* values in the parameter maps. A radial average profile outward from the rim of North Ray crater shows that *w* decreases steadily (**Fig. 3**) until reaching mature background areas. Compositional variations along these profiles are minimal, but the effect of fresh ejecta from North Ray crater on *w* compared to mature regolith ~2 km away from the rim (*w*~0.37) is evident. Future investigations aimed at determining the composition of the lunar surface using orbital photometric data should be aware of the effects of maturity on *w* values.

No clear trends between physical parameters and *b* and *c* values have been observed. The *b* and *c* parameters do not seem to be affected by I_S/FeO values; future work will involve comparing this parameter with OMAT. The variations in *b* seen in the ejecta of North and South Ray craters may be related to physical differences in the crater ejecta, rather than in maturity differences. Work is ongoing to assess the correspondence between photometry at the Apollo 16 landing site and the Cayley Plains Lunar International Standard Calibration Target (LISCT [10]) site.

Conclusion: Using Apollo 16 soil sample data and NAC-derived photometric parameters, we are able to better compensate for more feldspathic materials in the relationship between *w* and mafic composition. Extending this correlation allows us to more accurately estimate composition for regions that do not have ground truth data (e.g., areas of pure anorthosite [11], silicic volcanic regions [1], the Apennine Bench Formation [12]), using remote orbital photometric data.

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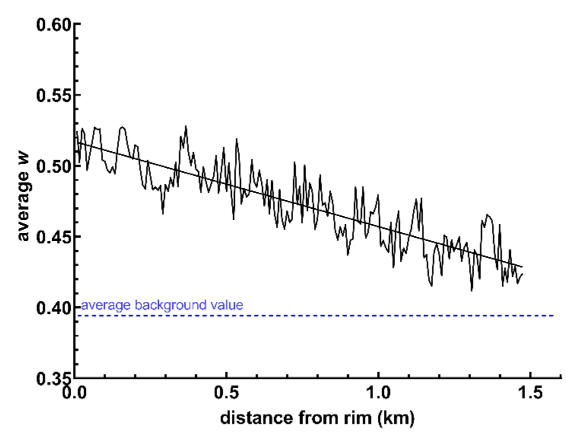

***Fig. 3**: Profile of w emanating from the rim of North Ray crater shows the effects of maturity on w.*

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