NEW INSIGHTS INTO THE LUNAR SURFACE FROM LROC NAC-SCALE PHOTOMETRIC INVESTIGATIONS.

R. N. Watkins[1,2], T. M. Hahn[3], B. L. Jolliff[2], S. N. Valencia[4], M. E. Banks[4], J. A. Grier[1], A. Schonwald[2], E. Culley[2], M. J. Watkins[6], B. Hapke[7], H. Sato[8], A. Boyd[3]. [1]Planetary Science Institute, Tucson, AZ, rclegg-watkins@psi.edu [2]Washington University in St. Louis, [3]School of Earth and Space Exploration, Arizona State University, [4]NASA Goddard Space Flight Center, Greenbelt, MD, [5]University of Maryland College Park, [6]Engineering Software Research and Development, Inc., St. Louis, MO, [7]University of Pittsburgh, [8]Japanese Aerospace Exploration Agency

Introduction: Photometry is a powerful tool for investigating differences in composition and regolith characteristics from orbital images. Specifically, photometric data from high-resolution Lunar Reconnaissance Orbiter Camera (LROC) Narrow Angle Camera (NAC) images, coupled with Apollo soil sample data and Hapke photometric modeling, can enhance our understanding of the geology of the Moon, as well as the photometric behavior and composition of lunar soil [e.g., 1-4]. NAC images and NAC stereo-derived digital terrain models (DTM) [5] enable us to assess how photometric parameters vary at the meter scale. Parameter maps can be correlated with soil sample data to interpret the physical and compositional properties of study regions [4; 6-7]. The important Hapke parameters for fitting NAC reflectance data are: ***w*** - single scattering albedo (primarily dependent on composition); and ***b*** and **c** (mainly dependent on physical grain structures, surface texture, and grain size) [6; 8-9]. Here, we discuss several areas of the lunar surface under investigation using photometric techniques, and the resulting implications for addressing outstanding lunar science questions.

Areas of Study: *Apollo Landing Sites.* The Apollo landing sites allow us to correlate photometric parameter maps (*w* and *b)* with sample data (composition, mineralogy, and grain size). Using data from photometric studies of blast zones [3] and Apollo 17 soil samples [7], we derived a correlation between mafic mineralogy and *w*. We extend the existing compositional relationships to feldspathic compositions using soil sample and photometric data from Apollo 16 (**Fig. 1**).

Pure Anorthosite: Investigations into the compositional diversity of purest anorthosite (PAN) are central to understanding processes that formed the Moon's primary crust. Evaluating NAC-derived *w* values, alongside Moon Mineralogy Mapper (M^3) spectral data, allows for robust analyses of compositional and mineralogical variations at outcrop scale [10,11]. Areas with plagioclase absorption features correlate with *w* values of ~0.6 and are likely areas of PAN [11].

Lobate Scarps: NAC photometric parameter maps and optical maturity datasets can be combined to better understand surfaces adjacent to lobate scarps and other young tectonic features on the Moon. The objectives of this work include: (1) understanding the characteristics of surface and near-surface materials disturbed by recent ground motion from seismic slip events during scarp formation; and (2) informing future landing sites. Preliminary results indicate changes in *b* values that may reflect effects of recent seismic shaking from slip events [12].

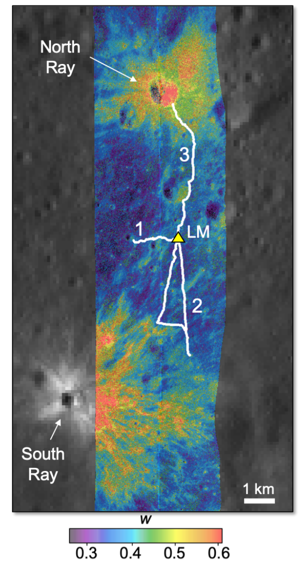

Fig. 1: NAC-derived w-map showing variations in local geology at Apollo 16 and the surrounding area (yellow triangle is the lunar module; white lines are the EVAs).

Volcanism: We are investigating several volcanic features on the Moon, including areas of silicic volcanism [4] and the Apennine Bench Formation (ABF) [13]. Understanding nonmare volcanism provides insight into the thermal history and crustal evolution of the Moon. Using the relationship between composition and *w*, recent work has shown that regions of nonmare volcanism have low mafic content (<5-10 wt% $FeO+MgO+TiO_2$), consistent with the occurrence of silicic materials [4]. The ABF likely represents the only large exposure of KREEP basalts on the lunar surface. Work by [13] includes examining the composition of the ABF and surrounding geologic units using photometry and M^3 data. Preliminary results show that the composition of the ABF reflects that seen in Apollo 15 KREEP basalts**.**

Acknowledgments: Portions of this work are supported by the NASA Solar System Exploration Research Virtual Institute (SSERVI) Cooperative Agreement NNH16ZDA001N, TREX team.

References: [1] Hapke et al. (2012), *JGR, 117.* [2] Kaydash et al. (2011), *Icarus, 211,* 89-96. [3] Clegg et al. (2014), *Icarus, 227,* 176-194. [4] Clegg-Watkins et al. (2017) *Icarus, 285,* 169-184. [5] Henriksen et al., (2017), *Icarus, 283,* 122-137. [6] Sato et al. (2014), *JGR-P, 119*, 1775-1805. [7] Hahn et al. (2019), 50th LPSC, Abstract #1976. [8] Hapke (2012), *Theory of Refl. and Emit. Spec.* (2nd Ed.). [9] Souchon et al. (2011), *Icarus, 215,* 313–331. [10] Jolliff et al., *this meeting.* [11] Schonwald et al. (2019), 50th LPSC, Abstract #1239. [12] Banks et al. (2020) 51st LPSC, Abstract #2903. [13] Valencia et al. (2020), 51st LPSC, Abstract #2293.