PHOTOMETRY, MINERALOGY, AND OPTICAL MATURITY OF LUNAR SURFACE FEATURES.

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Introduction: The spectral characteristics of lunar surface features can serve as a probe into the Moon's formation history. Improved remote sensing techniques reveal numerous compositional anomalies across the lunar surface. Here we discuss using photometry, mineralogy, and optical maturity (OMAT) to understand select lunar surface features as part of the Toolbox for Research and Exploration (TREX), a NASA SSERVI node. We focus initial investigations on the composition and physical characteristics of thorium (Th) anomalies and the implications regarding heterogeneities in the lunar crust.

Thorium Anomalies. Th is an important element for understanding lunar geochemistry and providing constraints for lunar evolution models. It is commonly used as a proxy for KREEP because it is easily detected from orbit [1,2]. Previous studies showed that nearly all small-scale Th anomalies are caused by highly evolved silicic volcanism [3-4], except for two localized anomalies (4-6 ppm) in SPA, near the Oresme V and Oresme U craters (Fig. 1), which are not clearly correlated with mare basalts or other volcanic features [5-7].

Methods: We use LROC NAC photometry, LROC WAC UV/Vis data, M^3 spectral data, and Lunar Prospector Gamma Ray and Neutron Spectrometer data in an ongoing investigation into the physical, compositional, and geochemical properties of the Oresme V-U Th hotspots. With these datasets, we can directly solve for the concentration of specific elements and/or mixing fractions of petrologic end members. Photometric and spectral properties reveal compositional information (i.e. are they KREEP-like or unique to the far side and/or SPA) that can also be compared to areas of similar Th and FeO contents at Apollo sites [8]. Additionally, we couple our photometric and mineralogical results with OMAT investigations to provide insight into relationships between soil maturity and particle size, roughness, and composition [9-10].

Preliminary Results: Preliminary analysis reveals no unique photometric anomalies at these locations, nor any obvious causative volcanic morphologies. OMAT values in this area are high only around small, bright-rayed craters, although subtle differences in OMAT (where not matured completely to background levels) may offer some insight into local maturation states. We will use these methods to investigate other lunar features, including areas of silicic volcanism that correlate to other Th anomalies (i.e., Compton-Belkovich Volcanic Complex), pyroclastic deposits, olivine outcrops, and cryptomare. Results will address scientific questions, provide clues to their origin, and support our understanding of materials important for future human and robotic exploration and ISRU activities.

References: [1] Reedy, R. C. et al. (1973) *JGR, 78,* 5847-5866. [2] Lawrence, D. J. et al. (2003) *JGR, 108.* [3] Jolliff, B. L. et al. (2011) *Nat. Geo., 4,* 566-571. [4] Glotch, T. D. et al. (2010) *Science, 329,* 1510-1513. [5] Jolliff, B. L. et al. (2000) *JGR, 105.* [6] Lawrence, D. J. et al. (2000), *JGR, 105.* [7] Hagerty, J. J. et al. (2011), *JGR, 116.* [8] Clegg-Watkins, R. N. et al. (2017) *Icarus, 285,* 169-184. [9] Grier, J. A. et al. (2001) *JGR, 106, 32,* 32847-32862, [10] Lucey, P. G. et al. (2000) *JGR, 105,* 20297-20305.

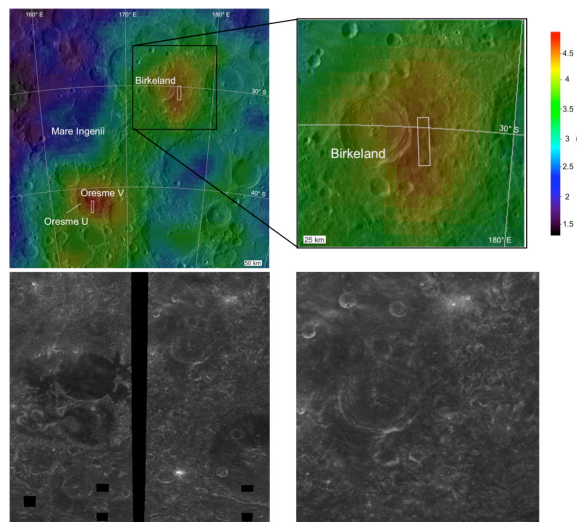

Fig. 1: SPA Th hotspots viewed in LROC WAC overlain with Lunar Prospector thorium data (top), and OMAT images (bottom).