LUNAR RECONNAISSANCE ORBITER LYMAN ALPHA MAPPING PROJECT (LRO-LAMP) DETECTION OF A GEOLOGICALLY YOUNG CRATER WITHIN THE FAUSTINI PERMANENTLY SHADED REGION.

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Introduction: The permanently shaded regions (PSRs) of the Moon are of great scientific and exploration interest because of their expected ability to trap and retain volatiles, potentially for >1 billion years (Gyr) [1-3]. Because they are never exposed to direct sunlight, the PSRs are difficult to study through remote sensing, but various instruments have managed to collect information about them at a range of different wavelengths and through particle detections. These observations provide information about the volatile content, surface properties and geological history of the PSR interiors. We provide new information about features inside PSRs using recently produced maps of the Lyman-α (121.57 nm) albedo of the interiors of two PSRs (illustrated in Fig. 1). These maps were produced using data taken by the Lyman Alpha Mapping Project (LAMP), a far ultraviolet (FUV) imaging spectrograph [4] on the NASA Lunar Reconnaissance Orbiter (LRO) [5]. These maps show that the ejecta blankets of two small craters (<2 km diameter) inside these PSRs have a higher Lyman-α albedo than the surrounding PSR. The higher albedo at Lyman-α is likely due to the ejecta blankets having lower porosity [6,7] than the surrounding PSR, suggesting that these two craters are relatively young on geologic timescales.

Lunar Regolith Porosity: LRO-LAMP measures the surface reflectance of the uppermost 25-100 nanometers of the lunar regolith in the wavelength range of 57-196 nm [4]. Previous studies of the FUV albedo measurements indicate that the porosity of the regolith in the lunar south polar PSRs is > 70% [6,8] compared to a lunar average of ~52% [9]. This is in good agreement with results from the Lunar Crater Observation and Sensing Satellite (LCROSS) which found that the Cabeus crater PSR has a porosity of ~70% [10].

The lunar regolith is formed by impacts and its composition varies spatially between basaltic and anorthositic, depending primarily on the composition of the basement rocks of the region. The porosity of the lunar regolith is determined both by the amount of free space between individual grains and the amount of space inside a grain. Higher porosity in the upper millimeters of lunar regolith will reduce the albedo across all wavelengths due to a greater absorption of photons [11], and provides the best explanation for the lower Lyman-α albedo observed by LAMP [6,7]. Regolith forms at a rate of 1.5 mm per 1 million years (Myr) and the top 1 mm and 0.1 mm of regolith turns over 250 and 2000 times, respectively, during that 1 Myr time period. Porosity of the top 15 cm is ~52% and decreases with depth to less than 40% below 200 cm [9]. Regolith is “weathered" by exposure to impact gardening [12] and the solar wind [13]. Impact gardening physically breaks down grains, buries more material than it exposes and heats and vaporizes regolith material that is then deposited on the surrounding material. It is predicted to completely overturn the top 1 mm of regolith within 1.2 Myr [12]. Exposure to the solar wind sputters atoms from the surface that are redeposited as a coating on the surrounding regolith. These weathering processes change the reflectance of the regolith as a function of wavelength, making them darker at visible wavelengths and brighter at relatively short FUV wavelengths.

A recent review of the ultraviolet (319-689 nm) spectra of fresh impact craters [14] observed with the Lunar Reconnaissaince Orbiter Camera (LROC) [15] found that the spectral characteristics of small crater (<5km) ejecta blankets indicated that the ejecta blanket was dominated by overturned soil rather than being dominated by primary ejecta like large craters. This suggests that the ejecta blankets of relatively fresh small craters will be brighter in Lyman-α due to a reduction in porosity resulting from overturn of regolith during the impact process.

LAMP PSR Observations: For this study we focus on two PSRs in the south polar region, illustrated in Figure 1. The PSRs of interest are the Faustini crater and an unnamed crater. The Lyman-α albedo of the Faustini PSR is 23% lower than the average albedo of the south pole region, while the albedo of the other PSR is 22% lower. Inside each of these PSRs is a bright region that appears to correlate with ejecta blankets of two small (<2 km) craters – labeled A & B.

Both A & B are simple craters formed by the impact of a meteor that was 10-1000 m wide, depending on the impactor density and impact velocity. The dimensions and ejecta blanket position of crater A suggest that it was formed by an oblique impact. The Lyman-α albedo of the ejecta blankets of both craters is higher than not only the PSR but also the average

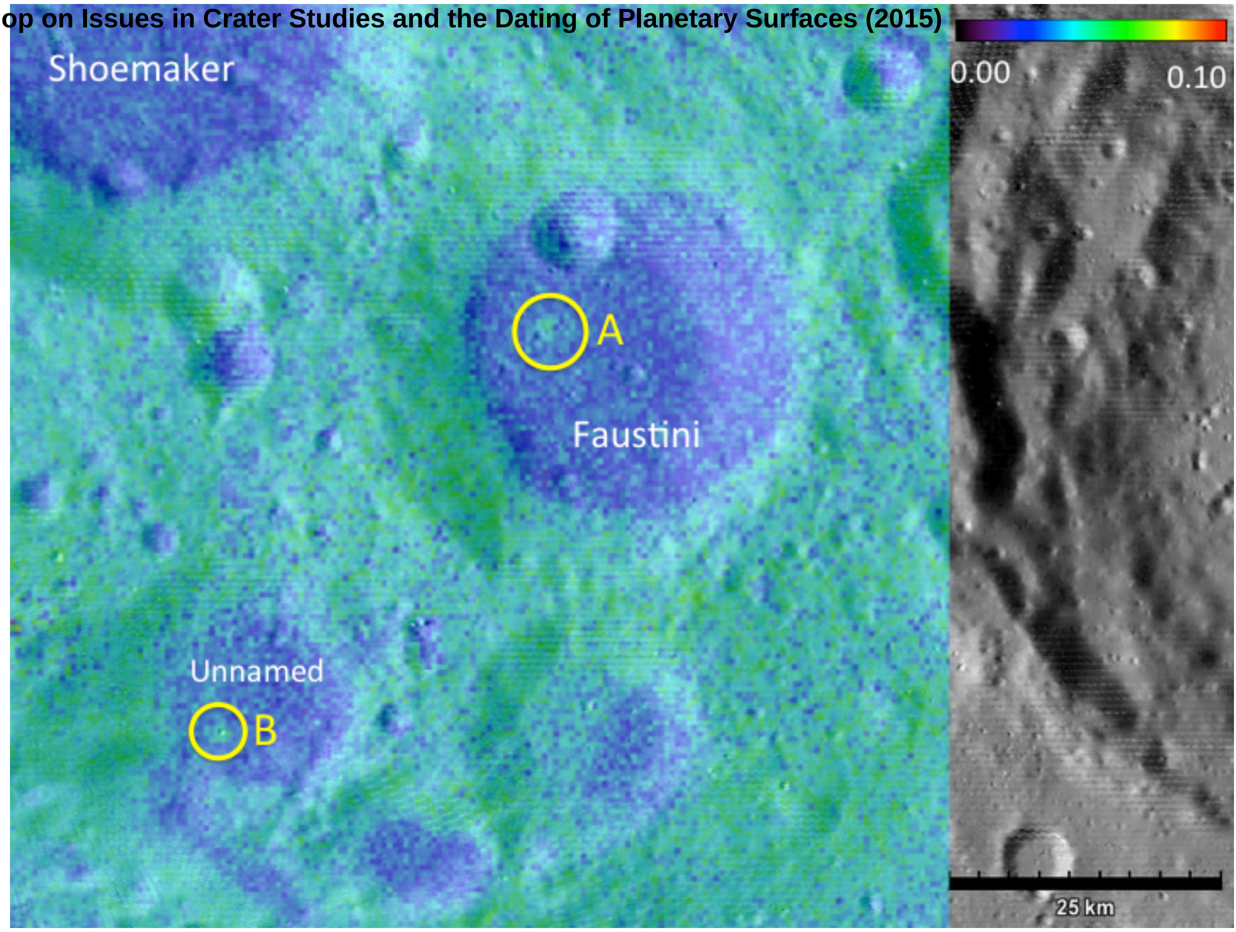

Figure 1 - LAMP Lyman- α albedo map of the lunar south pole PSR Faustini and an unnamed crater overlaid on a Lunar Orbiter Laser Altimeter (LOLA) [16] topographic map of the region. LAMP map pixel size is 500 x 500 m. The ejecta blankets of craters A & B, which have diameters of 1.0 and 0.8 km, respectively, are brighter that the rest of the PSR.

south pole albedo suggesting a relative difference in the porosity of the top layer of regolith. We interpret this observation to mean that these two craters are geologically younger than other similar sized craters within the PSRs because the deposition of the ejecta blankets has collapsed the porosity of the top layer of regolith, and the ejecta material has not yet undergone the processes that increase the porosity in the surface layer (e.g. production of “fairy castle” structures). We can place an upper age limit on these craters of ~1.2 Myr based on the timescale for impact gardening [2]. In this way, we have demonstrated a novel UV technique for the dating of planetary surfaces and furthering the study of craters within PSRs.

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