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Far-UV Observations of Lunar Rayed Craters

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Abstract

Lunar crater rays have been studied extensively at Ultraviolet-Visible (UVVIS) to Infrared (IR) wavelengths, but to date a comprehensive analysis in the far-UV has not been performed. We present an examination of crater rays using data from the Lyman Alpha Mapping Project (LAMP), a far-UV imaging spectrograph onboard the Lunar Reconnaissance Orbiter (LRO). LAMP is sensitive to space weathering effects and composition of the lunar regolith. Our findings, therefore, have implications for submicroscopic iron (SMFe) abundance of young crater ejecta, and can provide insight into the physical properties of the regolith at young craters such as Tycho.

1. Introduction

Previous studies of crater rays found that they have generally high visible albedos and optical maturity (OMAT) values, consistent with immature, unweathered regolith [4]. Near ultraviolet (NUV) observations similarly found that rays from highland craters displayed signatures of freshly exposed plagioclase soil [1]. The signatures of immaturity displayed by these young crater rays are largely due to a lack of SMFe in the rims of regolith grains at these regions. Maps of SMFe content produced by [3] and [7] derived from modeling of Kaguya Multispectral Imager (MI) data in fact show the crater rays to be depleted in SMFe.

LAMP is ideally suited to detecting relative regolith maturity/SMFe abundance due to the bluing and darkening effect of SMFe on a reflectance spectrum in the off-band (155-190 nm) wavelength range [2]. Regolith composition is another property that can be analyzed with LAMP. Minerals such as anorthite and ilmenite have distinct spectral slopes in the far-UV, and the abundances of these minerals can contribute to relative albedo differences between highlands and mare soils. Other properties such as regolith porosity and roughness may also have important spectral effects in the far-UV.

2. Observations

In this study, we analyze LAMP daytime data collected between October 2009 and October 2016. We make use of two LAMP data mapping tools: the Global Mapper and the Spectral Mapper. The Global Mapper accumulates data into broad spectral bands, enabling global spatial coverage at lower spectral resolution than the Spectral Mapper, which produces high spectral resolution data cubes over smaller areas of the lunar surface.

3. Results

The global off-band (155-190 nm)/on-band (130-155 nm) ratio map in Figure 1 shows that crater rays from young highland craters are some of the most prominent features on the surface. The rays of Tycho, Giordano Bruno, and Necho have the highest Off/On ratios on the surface. In the regional view of Tycho crater (Figure 2), we see a low ratio halo surrounding the crater in addition to the high ratios of the rays. This halo lines up well with the low visible albedo halo seen around Tycho at high Sun, previously suggested to be caused by impact melt deposits [5].

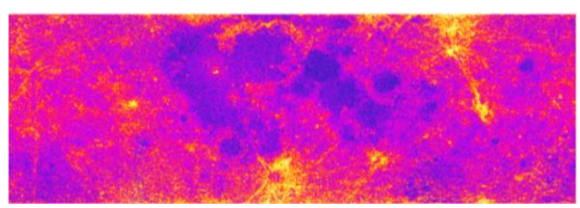

Figure 1: LAMP global daytime off-band/on-band ratio map. Highland crater rays display the highest ratios on the lunar surface.

We perform a far-UV spectral analysis of the different regions of Tycho's ejecta, and plot the resulting albedo spectra in Figure 3. The crater cavity and halo display high albedos across the full bandpass, and the crater ray has the lowest albedos in the region over the on-band. The ray is seen to have the reddest slope in the off-band, however, while the cavity and halo display similar slope to the background highlands material.

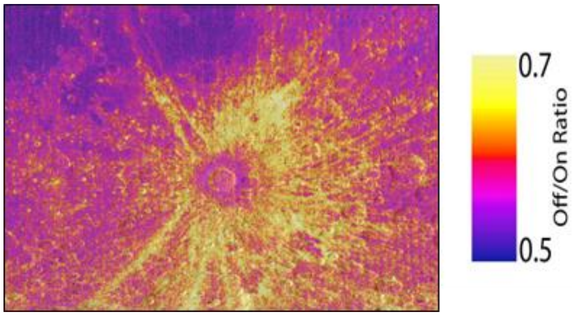

Figure 2: Off/On ratio map of Tycho crater. A low ratio halo surrounds the crater cavity, possibly due to the presence of impact melt glass.

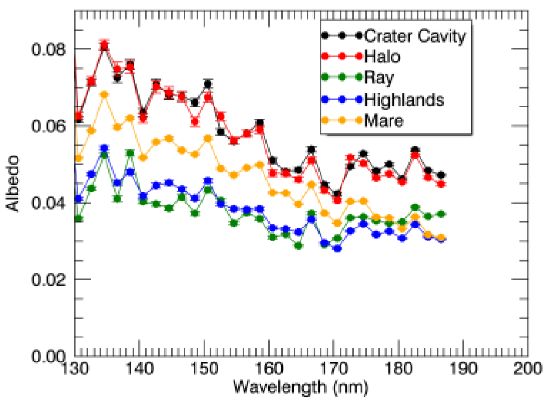

Figure 3: Albedo spectra of different regions of Tycho's ejecta. The ray has a red slope at wavelengths >170 nm, while the cavity and halo have similar slope to the background highlands.

4. Discussion

The high ratios of the highland crater rays are consistent with relatively unweathered plagioclase containing low amounts of SMFe. Low ratios in the halo surrounding Tycho would suggest that the material there is older and more weathered than in the rays. The halo and rays should have been emplaced at the same time, however, and should therefore be the same age. One potential explanation is a compositional difference between these two regions causing a difference in their spectral ratios.

One suggestion for the spectral difference in the halo around Tycho is impact melt glass being the predominant component of this region [5]. Previous studies have found that areas of pooled impact melt around Tycho may contain >50% quenched glass in a glass-lithic mixture [6]. If the glass has high Fe-content compared to the low-Fe highland rays, then that could cause the low ratio in the halo.

5. Summary and Conclusions

Rays originating from young highland craters display high Off/On ratio as measured by LRO-LAMP, consistent with low abundances of SMFe. Low ratio halos surrounding these craters likely result from the presence of impact melt glass, which may contain greater amounts of Fe than the low-Fe rays.

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