PHOTOMETRIC CHARACTERIZATION OF ON- AND OFF-SWIRL REGIONS OF THE LUNAR SURFACE:TEXTURAL SIMILARITIES AND DIFFERENCES.
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Introduction: There are many hypothesis that attempt to explain the distinctive lunar albedo markings known as swirls. The two hypotheses that are best supported by the spectral evidence include: 1) magnetic shielding of the surface from the solar wind, and 2) electrostatic dust transport and/or magnetic sorting of the fine-grained component of the regolith. These hypotheses will hereafter be referred to as the MS-theory and the EDT-theory, respectively.

Each hypothesis provides predictions for the comparative textural properties of the regolith and regolith grains between on- and off-swirl regions. In the MS-theory, off-swirl regions will have been exposed to solar wind ion bombardment at higher doses and longer time periods than on-swirl regions. This implies that the off-swirl regolith will be darker, redder, and the regolith grains will be more radiation-damaged than their on-swirl counterparts. Radiation damage creates scattering centers, thus making the grains more backward scattering. Large scale (millimeter or greater) roughness will not be affected, however grain surfaces will become rougher at wavelength scales. In the EDT-theory, on-swirl regions are enhanced in the small-grain (micrometer scale) feldspathic component, thus creating a brighter, potentially more intricate fairy-castle structure in the on-swirl region. In this case surface roughness differences can be expected, while grain scattering properties will remain similar.

One method for examining the regolith structure is to examine the photometric behavior of the surface. Photometric characterization of a surface can provide information on the physical structure of a surface (such as roughness) and the properties of the surface regolith grains (such as scattering behavior). This characterization is highly dependent on the accuracy to which the illumination and viewing conditions can be determined. We present photometric modeling results, using Hapke's set of equations [1 – 6], of swirl regions, using techniques that accurately characterize the topography of the local surface.

Stereophotoclinometry: Using Lunar Reconnaissance Orbiter Camera (LROC) data, we constructed a digital elevation model (DEM) for areas within the Ingenii and Reiner Gamma swirl regions using the techniques of sterophotoclinometry [7]. The selected regions contain both on- and off-swirl areas. The source LROC data has a resolution of 0.5 meters, while the SPC generated DEM has a grid spaceing of 5 meters. From the DEM images of illumination (incidence angle) and viewing (emission angle) geometries can be constructed (Fig.1).

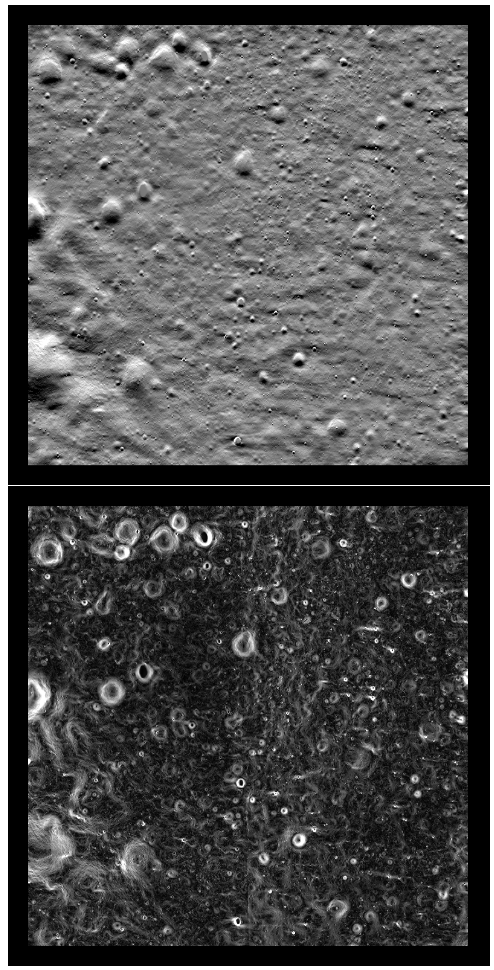

Figure 1. Incidence (top) and emission (bottom) for the Ingenii swirl region.

Photometric Analysis: Photometric cubes (layered images in which each layer contains specific data relevant to the pixel position within the cube) were constructed from each LROC image that fell within our regions. We generated a 4-band cube where the four layers contain the reflectance (I/F), phase angle (α), incidence angle (i), and emission angle (e). The I/F values come directly from the calibrated LRO NAC images. The phase angle is generated from the United States Geologic Survey (USGS) Integrated Software for Imagers and Spectrometers (ISIS) tool. Incidence and emission angles are calculated directly from the topographic SPC model using the spacecraft and sun positions. The NAC images are narrower than our regions, so multiple images are required to fully mosaic the selected areas.

The key component to generating the photometric cubes is the registration process performed by SPC. We use SPC to identify several thousand control-points (a.k.a. landmarks) in an image that locks its position to the existing DEM and registers it at one pixel accuracy. Once this is performed on all the images, any location within the working region (2,000 x 2,000 pixel) can be selected and the exact I/F for each observation of that surface feature, along with the associated α, i, and e can be retrieved. The data within the photometric cubes were modeled using Hapke's set of equations [1 – 6], where 10 x 10 pixel areas within the cubes defined a single data set to be modeled. The results are image cubes where the layers correspond to the parameter values for each parameter in the Hapke model (Fig. 2).

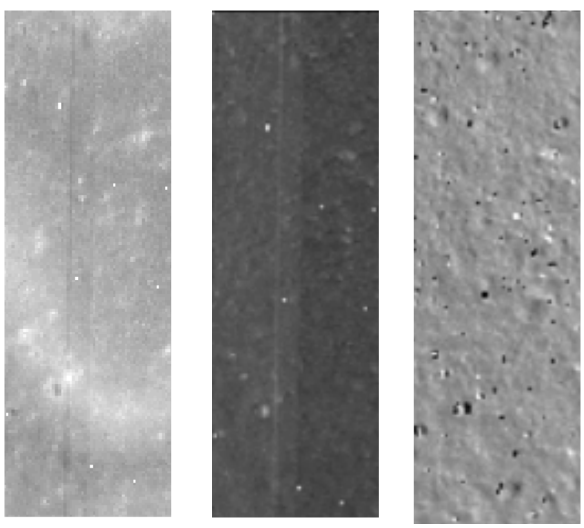

Figure 2. Hapke parameter values for a section of the Ingenii region studied. The single scattering albedo (left), the particle scattering function asymmetry parameter (center), and surface roughness parameter (right) are shown.

Photometric Results: Preliminary modeling results in the Ingenii region (Fig. 2) show single scattering albedo differences between on- and off-swirl regions, with the on-swirl area displaying higher (brighter) values. However, the particle scattering and surface roughness values are similar between on- and off-swirl regions, neither scenario supporting the MS or EDT theories. Reiner Gamma region values are still being calculated.

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