EPSC Abstracts
Vol. 6, EPSC-DPS2011-625, 2011
EPSC-DPS Joint Meeting 2011

Spectral analysis of Reiner Gamma on the Moon using the data from Spectral Profiler onboard SELENE/Kaguya

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Abstract

Space weathering causes the change in optical properties, such as darkening, reddening, and decrease of absorption depths of the planetary surfaces. Two competing processes have been proposed so far as the main mechanism of such space weathering; hydrogen irradiation by solar wind and bombardment of micrometeorites. We use the new data set obtained by Spectral Profiler (SP) onboard SELENE/Kaguya which observed the Moon and approach the actual process of space weathering on the Moon.

1. Introduction

Agents of space weathering are assumed to be particles of nanophase iron and/or glasses on the planetary surfaces, however, the process how they are produced is still controversial. Based mainly on the experimental studies, the two mechanisms are proposed: (i) spattering of the planetary surface with proton in solar wind (ex. [1]), and (ii) bombardment of micrometeorites (ex. [2]). We approach the mechanism of space weathering using the newly obtained remote sensing data by SELENE/Kaguya which observed the Moon. We focus on the albedo-contrasting features called lunar swirls uniquely observed on the Moon. The lunar swirls are enigmatic albedo features consisting of bright/white and dark/black parts making 'swirl' patterns. We investigate the optical characteristics of such albedo contrasts. The difference of albedo generally corresponds to the difference of composition, particle size, or extent of weathering of the surfaces. We target Reiner Gamma located at 7.5 deg. N and 59.0 deg. W, which is one of the most outstanding albedo markings of the lunar swirls. We study the potential connections between the albedo contrasts and space weathering at Reiner Gamma based on the spectral analysis using the data from Spectral Profiler (SP) onboard SELENE/Kaguya. We try to get clues for understanding the plausible mechanism of the space weathering on the Moon.

2. Data Analysis

SP is a visible and near infrared spectrometer covering 500-2600 nm in wavelength with spectral resolutions of 6-8 nm. The data gives very critical information about the extent of weathering as well as the identification of the mineralogical compositions with unprecedented accuracy. We follow [3] and [4] to calculate the relative reflectance to keep consistency with the Apollo 62231 sample [5]. Using such SP data, we investigated the following spectral parameters at the selected several points within each segment of contrasting albedo consisting Reiner Gamma's swirl pattern. First we fitted the continua for the observed spectra and examined the relationship between the albedo and the slopes of the continua. The slope of continua should be one of the parameters representing the maturity. Second we removed the continua from the spectra to get the compositional information. Then we deconvolved the continuum-removed SP spectra using Modified Gaussian Model (MGM) [6] to clarify the features of the absorption bands quantitatively.

3. Results

We found the systematic relationship between the albedo and the maturity, which are represented by the (1) reflectance at 0.75 micron (r0.75) and slopes of the fitted continua or (2) r0.75 and depth/strength of absorption band of 1 micron and 1.3 micron, respectively. As for the composition we found no systematic variation corresponding to the albedo contrast after MGM deconvolution. It is revealed the spectra have almost constant values for the central wavelengths of the absorption bands and the composition seems mainly pyroxene, with slightest variation. We detect no features of olivine, such as the characteristic absorption around 0.85 micron or the strong absorption centered at longer than 1.0 micron. We observe the systematic relationship between r0.75 and the maturity represented by the depth/strength of absorption band of 1 micron and 1.3 micron, too. Therefore the darker segment, which has lower reflectance at visible wavelength (0.75 micron), seems more mature than the brighter segment and vice versa. An increase of albedo accompanies decrease of maturity. The brighter sections/parts are materially more fresh than darker parts. The possible explanations would be that the darker parts were exposed to space weathering more intensively.

4. Conclusions and Discussion

Our spectral results show comparatively homogeneous composition among the segments with drastically different albedo. The difference of albedo (or reflectance at 0.75 micron) corresponds clearly to the degree of space weathering. The facts suggest the environment of space weathering is critically different from segment to segment with contrasting albedo. The brighter segments have been significantly prevented from weathering. Our results support the scenario that the magnetic shielding [7] had been worked at the area of bright segments in the Reiner Gamma and prevented from weathering by hydrogen. We conclude lunar space weathering could be induced by solar wind dominantly at least for the case of lunar swirls. The bombardment of micrometeorite solely might play only minor role on space weathering and not accomplish the space weathering.

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