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Global Mineralogical Surveys of the Moon by Kaguya Spectral Profiler

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Abstract

SP is a nadir looking spectrometer onboard Japanese lunar explorer, Kaguya. SP's wide spectral coverage and high spectral sampling interval are quite effective for global mineralogical surveys of the Moon. The automated one-by-one spectral examinations already found more than 200 olivine exposures as well as several crystalline plagioclase outcrops. The photometrically corrected and gridded SP global data set is also being used in the global survey.

1. Introduction

Spectral Profiler (SP) is a nadir looking visible - near infrared spectrometer onboard Japanese SELENE (Kaguya) lunar explorer launched in September 2007. SP consists of one reflective telescope, two plane gratings, three linear detectors, one three-stage peltier cooler, and two halogen lamps with a filter for radiometric and spectral calibration. Its spectral coverage and sampling interval, 0.5 - 2.6 µm and 6 - 8 nm, were optimized for the detection of spectral absorption features of lunar surface minerals. The along-track sampling interval is 500 m. The total number of SP's spectral channels is 296 including several overlapping channels around 1 µm.

The eleven-month-long nominal operation of SP was started in December 2007 just after the initial check out period. The extended mission of SP was started in November 2008 and ended in June 2009 with a controlled crash of Kaguya to the Moon. During the nominal and extended operation periods, SP acquired data from about seven thousand revolutions around the Moon and the total number of obtained lunar surface spectra is close to seventy million. The average east-west spacing between SP transects is 1 - 2 km at the equator. During most of SP observation, Terrain Camera (TC) or Multiband Imager (MI) was operated to obtain images which will be used to determine the exact locations of SP spectra by image-matching calculation in SP Level 2C product generation.

Early scientific findings using SP data include a large outcrop of crystalline plagioclase in Jackson Crater[1], the ultramafic impact melt sheet beneath the South Pole–Aitken basin[2], and the global distributions of purest anorthosite and olivine exposures[3][4].

2. Radiometric Calibration and Photometric Correction

SP radiometric calibration methodology was developed for SP Level 2B1 and 2B2 product generation. This methodology include non-linearity correction, wavelength shift correction, and the correction of the preflight radiometric calibration coefficients affected by the water vapor in the laboratory. The details of the methodology are described in [5]. All SP Level 2B1 and 2B2 are publicly available at JAXA's SELENE Data Archive website (https://www.soac.selene.isas.jaxa.jp/archive/index.html.en).

SP photometric correction methodology for 0.5 - 1.6 µm region was developed for SP Level 2C product generation. It is based on same radiative transfer formulae for particulate surfaces used in the previous study[6], but careful data screening procedures are newly introduced and coefficients in the formulae were determined independently for each SP spectral channel in 0.5 - 1.6 µm. The details of the methodology are described in [7].

The absolute accuracy of SP radiometric calibration was estimated to be ~ 2% [8]. The relative accuracy or the repeatability of SP radiometric calibration and photometric correction was estimated to be 0.4 - 1.1 % based on multiple observation data at Apollo 16 landing site [5].

3. Global Mineralogical Surveys

Currently, two types of the global mineralogical surveys using SP data are being conducted. The first is the automated one-by-one spectral data examination. This type of global survey is very effective to find small outcrops with minerals which have distinctive spectral features such as olivine and crystalline plagioclase. Figure 1 shows the locations of more than 200 olivine exposures extracted from nearly seventy million SP spectra[4].

The second is the surveys using photometrically corrected and gridded SP global reflectance data set. Figure 1, 2, and 3 are the SP 753 nm channel image, and the global color ratio and principal component color maps from 0.5 degree mesh data set. Note that although SP data were acquired under variable solar elevation, there are no residual artifacts in the images. This indicate that the accuracy of SP photometric correction is quite high. This type of survey is suitable for global analysis of subtle mineralogical and compositional differences.

References

[1] Matsunaga, T. et al.: Discoveries on the lithology of lunar crater central peaks by SELENE Spectral Profiler, Geophysical Research Letters, Vol. 35, L23201, doi: 10.1029/2008 GL035868, 2008.

[2] Nakamura, R. et al.: Ultramafic impact melt sheet beneath the South Pole Aitken basin on the Moon, Geophysical Research Letters, Vol. 36, L22202, doi:10.1029/2009GL040765, 2009.

[3] Ohtake, M. et al.: The global distribution of pure anorthosite on the Moon, Nature, 461, doi:10.1038, 2009.

[4] Yamamoto, S. et al.: Possible mantle origin of olivine around lunar impact basins detected by SELENE Nature Geoscience, doi:10.1038/ngeo897, 2010.

[5] Yamamoto, S. et al. : Preflight and In-Flight Calibration of the Spectral Profiler on Board SELENE (Kaguya), IEEE Transactions on Geoscience and Remote Sensing, in press, 2011.

[6] McEwen, A. et al.: Summary of radiometric calibration and photometric normalization steps for the Clementine UVVIS images, LPSC XXIX, #1466, 1998.

[7] Yokota, Y. et al.: Lunar photometric properties at wavelengths 0.5-1.6 μm acquired by SELENE Spectral Profiler and their dependency on local albedo and latitudinal zones, submitted to Icarus, 2011.

[8] Ohtake, M. et al.: Deriving the absolute reflectance of lunar surface using SELENE (Kaguya) Multiband Imager data, Space Science Reviews, Vol. 154, No. 1–4, pp. 57–77, 2010.

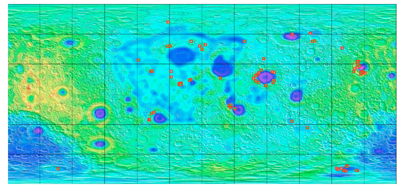

Figure 1. Global distribution of olivine exposures (red squares). The background is the lunar crustal thickness map from SELENE gravity measurements. (Red-yellow = thick, blue = thin.)

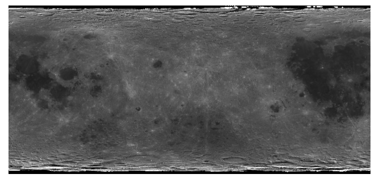

Figure 2. SP 753 nm channel image

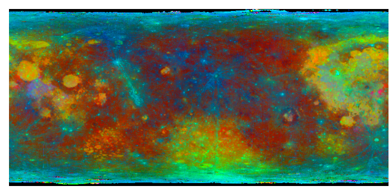

Figure 3. Color ratio map. (Red=1546 /753 nm, Green=753 / 945 nm, Blue=513/753 nm)

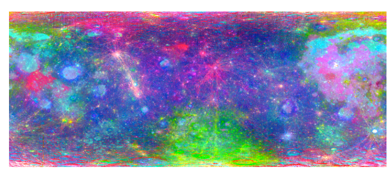

Figure 4. Principal component color map. (Red = PC2, Green = PC3, Blue = PC4)