STUDY OF THE OPTICAL STANDARD SITE FOR THE SELENE MULTIBAND IMAGER.

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Introduction: The Lunar Imager/ SpectroMeter (LISM) is an instrument being developed for the SELENE project that will be launched in 2005. LISM consists of the three subsystems, Terrain Camera (TC), Multiband Imager (MI), and Spectral Profiler (SP). The sub-systems share some components and electronics [1].

MI is a high-resolution multiband imaging camera consisting of two visible and near infrared sensors. MI takes push-broom imaging data by using selected lines of area arrays. The spectral band assignments are 415, 750, 900 and 1000 nm for visible and 1000, 1050, 1250 and 1550 nm for near infrared. The spatial resolution of visible bands is 20 m, and that of near infrared bands is 62 m from the 100 km SELENE orbital altitude. Specification of MI is shown in Table 1.

We will observe the global mineral distribution of the lunar surface in nine band images of MI. One of the most important scientific goals of MI is to search for most primitive lunar crustal materials by utilizing MI's high spatial resolution and high S/N. MI's high spatial resolution will also enable us to investigate small but scientifically very important areas such as crater central peaks and crater walls. Investigations of such small areas will help answer current questions such as the existence, chemical composition and source of olivine at the central peaks of some craters. The advantage of MI for this aspect is that we can remove topographic effect, which causes false pattern seen in the crater wall and crater central peak, by photometric correction with detailed topography. Digital terrain model is derived from TC stereoscopic images, or MI band sets, which has 10.5 degree in parallax.

Table 1 Specification of

	VIS	NIR
Focal length	65 mm	65 mm
F number	3.7	3.7
Field of view	11 deg	11 deg
Spatial resolution	20 m	62 m
Swath width on	19.3 km	19.3 km
Detector	2D CCD (1024 x1024 pixel)	2D InGaAs (320 x 240 pixel)
Pixel size	13 x 13 µm	40 x 40 µm
Detector cooler	N/A	N/A
Number of band	5	4
Band assignment	415 +/- 10 nm 750 +/- 5 nm 900 +/- 10 nm 950 +/- 15 nm 1000 +/- 20 nm	1000 +/- 15 nm 1050 +/- 15 nm 1250 +/- 15 nm 1550 +/- 25 nm
Quantization	10 bit	12 bit
S/N	> 100	> 300
MTF	> 0.2 @ Nyquist	> 0.2 @ Nyquist
Integration times	5.33, 2.66 and 1.33 msec	26.4, 13.2 and 6.4 msec
Data compression	DPCM (loss-less)	N/A
Compression rate	< 80%	-
Solar elevation angle in operation	30-90 deg	
Data amount	49.0 Gbit/day	

Manufacturing and integration of MI flight model have been completed (Figure 1). Measurements of MTF, viewing vector, (brief) stray light and electrical noise level were carried out after the integration. Measured data indicate that MI will provide sufficient MTF, low noise and low stray light spectral imaging data just as estimated in the MI designing phase [2]. As a result of continuous effort, intensity of cross talk among spectral bands is kept especially low.

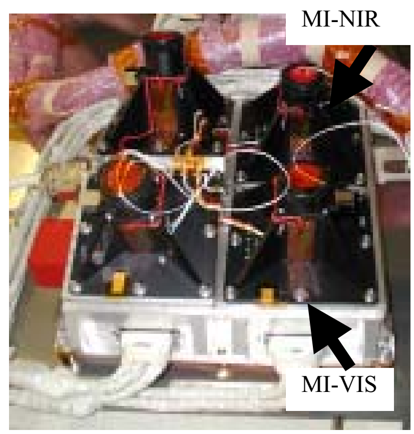

Figure 1. Flight model of LISM LRU (LISM Radiometric Unit).

Purpose of this study: MI will take images of the whole surface of the moon during one year SELENE mission. For the data calibration we are planning to take several images of the same standard area under different phase angle condition throughout the mission period. We have started studies for selection of optical standard area best for the MI data. Apollo 16 landing site is one of the most useful standard site because this area is widely used in both of earth-based and remote sensing moon observation data. Matured, homogeneous and low reflectane rectangle area near the Apollo 16 landing site was selected as an optical standard area, which is also used in the previous lunar observation study, for the Clementine UV/VIS camera based on the intense studies [3][4]. Apollo sample 62231 was used as a reflectance standard for the data conversion to reflectance [5] with assumption that this sample has representative reflectance properties of this standard area [4].

Even though the successful calibration of the Clementine UV/VIS camera, MI's higher spatial resolution or other instrumental properties such as high S/N and low stray light probably required standard area for MI own. Our purpose of this study is to re-evaluate optical properties of the Apollo 16 landing site and select the best standard area for the MI.

Methods: We measured bidirectional reflectance spectra of 5 Apollo 16 regolith samples (from 400 to 2500 nm at i=30 and e=o). 5 samples were selected (listed in Table 2) to understand variety of optical property of each geological unit of this area. Obtained spectra were compared to the spectra of sampling spots pixels in the Clementine PDS mosaic data [5]. Curve fitting calculation using Modified Gaussian Model (MGM) [6] were applied to the derived sample spectra to understand the relation between the reflectance properties and the mineralogy of the samples.

Table 2 Description of studied Apollo samples.

Sample No.	Description
60501	Soil at LM landing site.
62231	Soil at Station 2 Buster crater rim.
63501	Soil at Station 13 rich in North Ray crater ejecta.
67601	Soil at North Ray crater, highland component mixtures.
66041	Soil at Station 6 white ray material.

Results: All sample spectra (Figure 2-a) indicate weak pyroxene absorption signatures at around 1000 and 2000 nm. Absolute value of the obtained reflectance is higher in the order of sample 67601, 63501, 66041, 62231 and 60501. Reflectances at 750 nm are 32.0, 26.0, 20.8, 20.5 and 19.3 % (given in the order of sample numbers). To estimate the effect of compaction rate and surface roughness to the obtained reflectance value, we measured reflectance of Apollo samples under different compaction and surface conditions. In our study the variation caused by these effects is up to 25 % of the reflectance value. This variation must be considered to use laboratory measurement of Apollo sample as a reflectance standard. Reflectances thus obtained, and the correspondent reflectances in the Clementine mosaic data are very consistent with each other in the order of reflectance. Scaled reflectance (Figure 2-b) indicates that sample 67601 and 63501 are less matured than other samples. Real variation of reflectance less than special resolution of the Clementine UV/VIS camera have not known but in the Clementine mosaic data higher reflectance area show higher special variation of reflectance. Variation of reflectance for each sample in the order of higher reflectance is 28.2-25.7, 23.8-22.6, 21.6-20.3, 21.5-20.8 and 20.8-20.0 % within 3 3 pixels around sampling spots. MGM calculation shows that there is variation among samples of absorption peak center as indication of mineral composition of samples. The variation is clear at the peak around 2000 nm and it is about 90 nm among 5 samples with largest peak center of sample 67601.

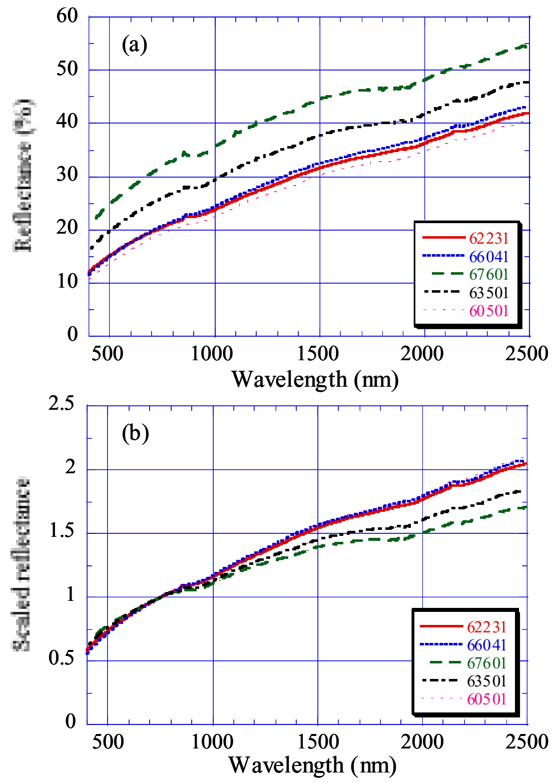

Figure 2. Reflectance spectra of (a) 5 Apollo16 samples and (b) scaled reflectance at 750 nm under the condition of i=30 and e=0 degree. Individual spectrum shows averaged value of several measurements. Sample 62231, 66041 and 60501 show lower and "redder" reflectance.

Conclusions: From the fact that sample 60501 show lowest and space-weathered (even though not most weatherd) reflectance and 60501 sampling spot has homogeneous property we are considering this sample can be the reflectance standard for MI same as sample 62231. Also MI probably prefers the Apollo sample sampling spot (lower and homogeneous reflectance area among the sampling spots) directly as optical standard site using advantage of high S/N ratio. Further study on the mineralogy of the Apollo samples will be need before the MI observation.

We thank NASA for the Apollo samples.

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